Stock Delineation and Growth of Rock Sole *(Lepidopsetta bilineata)* as Indicated by Tagging in British Columbia Waters, 1944-66

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STOCK DELINEATION AND GROWTH OF ROCK SOLE (*Lepidopsetta bilineata*) AS INDICATED BY TAGGING IN BRITISH COLUMBIA WATERS, 1944-66

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ABSTRACT

Ketchen, K. S. 1982. Stock delineation and growth of rock sole (Lepidopsetta bilineata) as indicated by tagging in British Columbia waters, 1944-66. Can. MS Rep. Fish. Aquat. Sci. 1683: iii + 41 p.

An inventory is provided of taggings conducted during 1944-66 together with results from Hecate Strait and Queen Charlotte Sound where most of the work was conducted during 1947-66. Neglecting first-year returns, 95% and 86%, respectively, of the recaptures were made within 15 miles of the tagging sites in the two areas. No intermingling was indicated between northern and southern Hecate Strait. In Queen Charlotte Sound minor and unconfirmable numbers of migrants were noted from Goose Island Grounds to the adjacent Scott Island Grounds, but not the reverse. No recaptures from tagging in the Sound were reported from Hecate Strait or the west coast of Vancouver Island. It was concluded that rock sole occur in a number of localized stocks along the British Columbia coast. Growth of rock sole as indicated by tagging and by age determination from otoliths was compared and revealed some disparities which may reflect errors in age determination of old fish comprising a relatively small fraction of the exploited stocks.

Key words: rock sole, migration, stocks, growth.

RÉSUMÉ

Ketchen, K. S. 1982. Stock delineation and growth of rock sole (Lepidopsetta bilineata) as indicated by tagging in British Columbia waters, 1944-66. Can. MS Rep. Fish. Aquat. Sci. 1683: iii + 41 p.

Le présent rapport comprend un répertorie des étiquetages effectués de 1944 à 1966 en plus des résultats recueillis dans le détroit d'Hécate et le bassin Reine-Charlotte où la majorité des travaux a été réalisée de 1947 à 1966. Si l'on omet les étiquettes récupérées au cours de la première année, 95 % et 86 % desrecaptures ont été efectuées en deçà de 15 milles des emplacements d'étiquetage dans les deux régions respectivement. Les résultats portent à croire qu'il n'y a aucun mélange entre le détroit d'Hecate septentrional et méridional. Dans le bassin Reine-Charlotte, on a observé un petit nombre non confirmé de poissons qui migraient des pêcheries de l'île Goose aux pêcheries adjacentes de l'île Scott, mais non dans la direction inverse. Aucune recapture de poissons étiquetés dans le bassin n'a été effectuée dans le détroit d'Hécate ou sur la côte ouest de l'île Vancouver. On en conclut que la sole du Pacifique est présente dans un certain nombre de stocks localisés le long de la côte de la Colombie-Britannique. L'étude de sa croissance au moyen des données d'étiquetage et les résultats de l'otholithométrie font l'objet d'une comparaison et révèlent des divergences qui peuvent cependant découler d'erreurs dans la détermination de l'âge des vieux poissons, lesquels constituent une fraction relativement faible des stocks exploités.

Mots-clés: sole du Pacifique, migration, stocks, croissance.

INTRODUCTION

This report has a dual purpose: (1) to provide an inventory and general summary of rock sole (Lepidopsetta bilineata) taggings conducted in British Columbia waters, and (2) to examine in detail the results obtained in Hecate Strait and Queen Charlotte Sound where to date most of the tagging has been conducted. Although primary consideration under the latter topic will be given to dispersion and definition of stocks, growth as indicated by tagged fish will also be examined and compared with results of age determination from otoliths.

PART I

INVENTORY

From 1944 to 1966 the Fisheries Research Board of Canada (FRB) conducted tagging experiments on a number of flatfish species as part of a general life-history study of groundfish contributing to the otter-trawl fishery along the west coast of Canada. Among these species was the rock sole, a species of subarctic and trans-Pacific distribution (Hart 1973), particularly abundant on grounds in Queen Charlotte Sound (Area 5A and 5B in Fig. 1) and Hecate Strait (Areas 5C and 5D).

For convenience, the taggings have been treated according to two time-periods to distinguish those that were part of the preliminary or exploratory phase (1944-46) of the program from those of a more directed nature (1947-66).

YEARS 1944-1946

These early taggings of rock sole were conducted aboard commercial trawlers either during the course of their regular fishing operations or while under charter to FRB. A total of 826 fish was tagged and only 26 were recaptured (Table 1). The low rate of return (3%) can be attributed to a number of factors: conditions for tagging fish in good condition were far from ideal; fishermen and shore-workers had not been educated to the purpose of tagging; and the largest taggings were conducted in areas that either never had any significance to the fishery (Johnstone and Queen Charlotte Straits in the northern part of Area 4B) or were still not extensively fished by Canadian fishermen (Area 5C). An additional factor, not known at the time, was that nickel pins used in attaching the Petersen disc-type tags were vulnerable to corrosion by saltwater and hence subject to a high rate of shedding.

YEARS 1947-1966

With acquisition of the research trawler INVESTIGATOR NO. 1, in 1947, and later the A. P. KNIGHT, it not only became possible to tag rock sole and other groundfish in large numbers, but also to gain greater control over the condition of fish when tagged. Short hauls and the use of a large canvas holding tank served to increase greatly the viability of captured fish. In all, 10,394 rock sole were tagged during 1947-66, with all but one tagging taking place in either Queen Charlotte Sound or Hecate Strait (Areas 5A to 5D) (Table 2).

During the 1940s and early 1950s tags used were of the Petersen-disc type, attached with a nickel pin. By 1953 nickel was abandoned in favor of stainless steel wire/pins in light of results of a study (Forrester and Ketchen 1955) which demonstrated that stainless steel was much less subject to corrosion by seawater.

Recaptures from all of the 1947-66 taggings amounted to 1,399 or 13.5%, but varied widely (0-29%) from project to project. Although tag loss due to corrosion was one factor limiting returns there were numerous other reasons and these will be dealt with in the more detailed study below.

PART II

RESULTS OF ROCK SOLE TAGGING IN HECATE STRAIT AND QUEEN CHARLOTTE SOUND

HECATE STRAIT

Review of tagged fish releases

Major taggings were conducted in the northern half of Hecate Strait (Major Area 5D) in 1947, 1948, 1958 and 1959. These are identified as Projects 1, 2, 8 and 11 in Table 2 and the localities (more than one in each of 1947 and 1948) are shown in Figure 2 as the cluster within Minor Area 4). All were on what will be referred to as the "Butterworth Grounds" lying within a few miles of the steep edge of the Hecate Strait bank running from the latitude of Butterworth Rocks southeastward to the latitude of Warrior Rocks.

Elsewhere in Area 5D there were three small taggings, two in Minor Areas 2AE and 5U (Projects 8 and 9) and one not shown in Figure 2 on a ground in Minor Area 1E of Dixon Entrance near the entrance to Masset Inlet (Project 13 in Table 2).

In southern Hecate Strait (Major Area 5C) there was one small release on the "Ole Spot" in Minor Area 2BE (Project 14).

In all, 6579 rock sole were tagged in Hecate Strait between 1947 and 1966.

Review of recaptures

Returns from Butterworth taggings

Returns from the Butterworth taggings are treated as a unit in Table 3 to show the distribution in respect to time of recaptures during the first year at liberty, and in Table 4 by years following release. The recapture patterns from the 1947 and 1948 tagging reflected the seasonal nature of rock-sole-directed fishing effort. In the 1940s and 1950s the fishery took place primarily during the May to September period. Rock sole seemed to disappear from the Butterworth Grounds in the fall and not to return until the approach of the following summer--thus the paucity of tag returns during the 5th to 9th months (Table 3).

A similar pattern of recaptures failed to emerge from the 1958 and 1959 taggings because of marketing problems which became most apparent in 1959 when there was a virtual cessation of rock sole fishing from August through May 1960 on the Butterworth Grounds, and somewhat below-average production for several years thereafter. The marketing difficulty stemmed partly from weak demand but also from an unusually high abundance of small rock sole just under the minimum market size. The presence of these fish--vanguard of the exceptionally strong 1953 and 1954 year classes (Forrester and Thomson 1969:37)--discouraged fishing on the Butterworth Grounds. This event was reflected in the high proportion of unmarketable small fish (<31 cm) tagged in 1958 and 1959 compared with 1947 and 1948 (Table 5).

From those tag returns accompanied by precise information on the place of recapture it is possible to determine the approximate extent of dispersion from the Butterworth tagging sites, i.e. the net, straight-line distance between release and recapture sites. Such information, excluding recaptures made within 12 mo of the date of tagging, is summarized in Table 6. From all of the Butterworth taggings nearly 60% of recaptures were made 5 mi or less from the tagging sites and 85% were recaptured within 10 mi. For comments on the accuracy, as opposed to precision of tag recapture information, the reader is referred to Appendix 1.

Evidence of within-season and within-area movements has already been noted by Forrester and Thomson 1969:13) viz. recaptures in 1949 from the 1948 tagging first appeared on grounds adjacent to Warrior Rocks in the month of May and by August entirely on grounds adjacent to Butterworth Rocks. This northward movement within Minor Area 4 suggested that spawning, which is believed to take place in late winter, occurs somewhere to the south of 54°00'N. Just how far south was apparent neither from the month to month pattern of fishing nor from tag returns.[1]

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[1]It was not until April, 1982 that spawning concentrations were first found in an as yet incompletely defined area at about 53°45'N, immediately off the southeast quadrant of the compass rose in Fig. 2 (J. Fargo, pers. comm.).

Of interest in addressing the stock identification question is the fact that only three (1.4%) of the recaptures were made allegedly more than 35 mi from the tagging sites (i.e. outside of Minor Area 4). Of these, only one can now be fully confirmed. (For explanation of the procedure for accepting or rejecting tag recapture information see Appendix 2.) The tagged fish was recovered on the Shell Ground (18 mi southwest of White Rocks, virtually on the boundary between Minor Areas 2AE and 5U, about 7 mi north of the Major Area 5C-5D boundary (see Fig. 2). The more precise of the two unconfirmed recaptures was made on the White Rocks ground (8 mi southwest of White Rocks). This and the confirmed tagged fish had been at large 8 and 5 yr, respectively.

While it is tempting to conclude from the Butterworth taggings that rock sole diffusion out of Minor Area 4 is a negligible and slow process, two difficulties force a less positive view. First, in light of the absence of rock sole and/or lack of directed fishing for that species during all but a few months of the year, it is conceivable that substantial movement of a seasonal nature out of Minor Area 4 and back could have gone undetected. Second is the question of the relative vulnerability of rock sole to capture inside and outside Minor Area 4. To the extent that catch is a reflection of directed fishing effort, it is apparent from Table 7 that, in the several years immediately following the 1947-1948 and 1958-1959 taggings on the Butterworth Grounds (Minor Area 4), there was relatively little opportunity for recaptures in adjoining minor areas, if indeed such dispersion had occurred. The closest area of significant directed fishing for rock sole was in Minor Area 2BE (in Major Area 5C) which encompassed the "Ole Spot" and "Horseshoe" grounds some 50 to 70 mi south of the 1947-1959 Butterworth tagging sites. Yet no recaptures (either confirmed or unconfirmed) were reported from these grounds.[2]

Returns from other than Butterworth taggings

In regard to results of tagging on grounds other than Butterworth, four small releases were made between 1958 and 1966, as already noted in Table 2 (Projects 9, 10, 13 and 14). Sites of the first two in 1958, as shown in Fig. 2 were in the southern part of Major Area 5D: one each in Minor Areas 2AE and 5U (White Rocks Ground). Although nearly 700 fish were tagged only one recapture was reported. Recaptures from the 1966 taggings, Project 13 in Dixon Entrance (Minor Area 1E) and 14 on the "Ole Spot" (Minor Area 2BE) were only slightly better, being 7.6% and 2.4%, respectively. Details are provided in Tables 8 and 9.

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[2]In light of these results, an unconfirmed recapture on the Horseshoe Ground of a fish released from a very small tagging in 1946 on the Butterworth Grounds (one of 10 recaptures--Table 1) can be regarded as highly improbable.

Low recapture rates from taggings in all but the last mentioned area are not surprising in view of the low level of fishing for rock sole prevailing in those areas during the years of tagging and immediately thereafter (Table 7). Of course, other factors could have been involved. For example, the tagging in Minor Area 2AE (Project 9) was conducted primarily on unmarketable sizes of fish (Table 10) and in the presence of moderate numbers of dogfish, which could have inflicted a high mortality on tagged fish as they returned to the ocean bottom. Yet the tagging in nearby Minor Area 5U, which also yielded a near-zero recapture rate, was conducted in the apparent absence of dogfish.

In any event it is pertinent to note that none of those fish from the four above-mentioned releases was recaptured in the Butterworth area (Minor Area 4) or in any areas other than the tagging sites. If rock sole engage in significant movement from southern to northern Hecate Strait or even from the southern to northern part of Major Area 5D alone, it was not demonstrated by the 1958-1966 taggings.

There is no evidence of intermingling between Major Areas 5C and 5D and nothing to suggest significant movement among minor areas.

QUEEN CHARLOTTE SOUND

Review of tag releases

In Queen Charlotte Sound the principal areas for fishing rock sole are on Cook Bank in Major Area 5A and on Goose Island Bank in Major Area 5B. Along the northern edge of Cook Bank, usually called the Cape Scott Ground, but here referred to as the Scott Island Grounds, taggings were conducted in 1954 and 1960 (Projects 7 and 12 in Table 2). Three taggings were conducted in 1952-1954 on the northeastern side of Goose Island Bank (Projects 3, 4, and 5 in Table 2).

The approximate positions of these Queen Charlotte Sound releases (3,300 in all) are shown in Fig. 3. Length compositions of tagged fish, unlike those in Hecate Strait, contained only minor differences in the proportions of marketable and unmarketable-sized fish (Table 11).

Review of recaptures

The patterns of recapture in respect to time, both within the first year and by years following release, are summarized in Tables 12 and 13, respectively. The former reflect the highly seasonal nature of the fishery, which, during the 1950s and early 1960s was confined primarily to the months of May to September. This fishing season was dictated mainly by weather conditions but availability of rock sole may also have been a factor.

Rock sole in Queen Charlotte Sound were also fished by trawlers from the State of Washington, which accounted for about 21% of the tag recaptures.[3]

Returns from the Scott Island taggings

Among those recaptured fish that were at liberty 12 mo or more and were accompanied by precise information on place of recapture, 41% were reported within 5 mi of the point of release, 61% within 10 mi and 81% within 15 mi (Table 15). These percentages are altered little by inclusion of first year recaptures, viz 42%, 64% and 84%, respectively.

A detailed examination of the numerous recaptures from March to September in the year following the 1960 tagging (Project 12) displayed no pattern to suggest either a geographical or a bathymetric direction of migration. Thus there are no clues as to where the Scott Island rock sole stock spends the winter months.

The three most distant recaptures (29 mi) were to the southward, through the Scott Island chain to Cape Palmerston, but these do not meet the full confirmation requirements. No confirmable returns were reported from Goose Island Bank by Canadian fishermen, but seven, lacking precise information on location, were submitted by U.S. fishermen and shoreworkers. A reported recapture in Hecate Strait likewise has been rejected because of the fact that some U.S. fishermen were known to include Queen Charlotte Sound in their definition of Hecate Strait.

Returns from Goose Island taggings

Reported dispersion of tagged rock sole from Goose Island Bank projects is less reliable than that determined from taggings in other areas. Before the advent of LORAN the skipper of a vessel could usually identify only the particular edges or corners of this bank. Since the edges are 20-30 mi long and far from reliable land-marks, precise reporting of fishing location was impossible. Likewise, some releases along the northeast edge could not be pin-pointed.

Nevertheless, among those recaptures for which release and recapture points are identifiable, 30% were reported within 5 mi, 52% within 10 mi and 76% within 15 mi of the place of release (Table 15). Among 13 (22%) recaptured at a distance of 21 mi or more, four were reported from the southeast edge and southeast corner of the bank.

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[3]There are no records of the U.S. share of rock sole landings from Areas 5A and 5B prior to 1956 to compare with the share of returns from all taggings, but in the 1956-1960 period the catch share was about 15% (see Table 14).

The remaining nine recaptures are of special interest in as much as eight were reported from the Scott Island Grounds in Area 5A across the deep gully from Goose Island Bank, and one was reported from the Virgin Rocks Ground near the mainland. Notwithstanding the fact that none of these recaptures meets the confirmation criteria, details are provided in Table 16 for the convenience of future investigators who may regard the criteria to be too demanding. Two returns (D8842 and M4510) could not be matched to trip reports, and, according to computer records, the remaining seven came from trips during which the vessels fished on Goose Island Bank as well as on the ground where recapture was reported. A closer check of the data cannot be made because the original records were destroyed by a fire.

In passing it is perhaps worth noting in Table 16 that all but one of the fish (D4510) was a female of considerably above-average size at time of recapture. All but the same exception had been at large at least 24 mo.

Also, a few words should be said about the implied route of migration, if indeed some of the recaptures on the Scott Island Grounds are valid. Goose Island Bank is separated from the Scott Island Grounds (Cook Bank) by the Goose Island Gully which has a depth of 100-160 fa. Individual rock sole have been encountered in research vessel trawling along the edges of the gully to depths of 80-87 fm (Westrheim 1967; Harling et al. 1973) but never at greater depth.[4] Presuming that the species does not traverse the gully in midwater, the route would have to be around the eastern reaches of Queen Charlotte Sound and part of Queen Charlotte Strait (as approximated in Fig. 4). The recapture of a tagged rock sole on the Virgin Rocks Ground (in the Sea Otter Group, Fig. 4) adds credibility to this hypothesis. If true, it means that the minimum net distance travelled from Goose Island Bank was more like 70-80 mi than the straight-line distances given in Table 16 (24 mi from the northeast corner and 53 mi from the northwest corner). These remarks notwithstanding, the reader should not lose sight of the fact that an overwhelming number of the rock sole tagged on Cook Bank and on Goose Island Bank (97% and 82%, respectively, excluding first year returns) showed no evidence of intermingling.

It should also be remembered that no valid recaptures on any of the Hecate Strait grounds have been reported from the Queen Charlotte Sound taggings. Nor have these taggings yielded valid recaptures from the main fishing areas off Vancouver Island from Quatsino Sound to the international boundary (Major Areas 3D and 3C--Fig. 1).

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[4]Over 250 bottom hauls were made from 1963 to 1976 at depths of 90-150 fm in Goose Island Gully in connection with research on Pacific ocean perch. Maximum depth of rock sole distribution as indicated by commercial landing records (Smith and Forrester 1973) exceeded 100 fm but such records are sensitive to errors in reporting and therefore must be discounted.

GROWTH AS INDICATED BY TAGGING

To compute a von Bertalanffy growth curve for rock sole from lengths at time of tagging and at recapture, data have used from (a) female fish only, (b) fish captured during the eleventh to thirteenth month at liberty, and (c) fish measured by the FRB port observers at time of landing. The increment of growth, i.e. the length at time of recapture (ℓ_{i+T}) minus the length at time of tagging (ℓ_i) was plotted against length at time of tagging. The equation for the resulting linear regression is

$$\ell_{i+T} - \ell_i = L\infty(1-e^{-KT}) + \ell_i(e^{-KT}-1).$$

Given that T averages 12 mo or 1 yr, one can then solve for K, the growth completion rate, and $L\infty$, the asymptotic length in centimeters. These estimates from the Butterworth, Goose Island and Cape Scott tagging data are provided in Table 17 along with those derived by other authors using independent age-length data. Where comparisons can be made the differences in estimates of parameters appear large but actually are less when the growth curves for ages 5 to 13 are plotted as in Fig. 5. The starting point for lengths-at-age calculated from tagging data was arbitrarily set as the same length as that determined from otoliths for fish of age 5 yr.

For the Butterworth area, data of Forrester and Thomson (1969) are considered more appropriate for comparison with tagging results than those of Stocker (1982), because the former apply to a time period closer to that represented by the tagging data. There is good agreement for ages 6 to 9, after which there is a substantial drift to larger average lengths for ages estimated from otoliths. This differential could be caused by a progressive tendency to under-estimate the age of older fish and would be a serious error if it were not for the fact that from 1945 to 1959, 84% of the estimated numbers of female rock sole caught each year were 7 yr of age or less (Forrester and Thomson 1969: Table 27).

An alternative possibility is that growth rate of fish tagged in 1958 and 1959 reflected the high-density, slow-growth conditions that appeared to affect the 1952 to 1955 year classes (Forrester and Thomson 1969: Fig. 12). However only 1% of the pairs of data used in calculating estimates for the Butterworth Ground in Table 16 were from the 1958 and 1959 taggings. Thus a density factor does not appear to explain the disparity in Fig. 5.

The comparison of growth curves for the Scott Island Grounds in Fig. 5 shows a different form of disparity with estimated lengths of tagged fish of intermediate age being higher than those estimated from age-length analysis. There is no ready explanation for this modest divergence, but it should be remembered that while the age-length data applied to 1959-1969, the tagging data applied to 2 yr only (1955 and 1961), and may be within the error limits of the former. More important, however, is the possibility that the two sets of data were affected differently by selection at younger ages, in

which case the technique of comparison is inadequate. For example, if the starting point (where recruitment is complete) for lengths-at-age was set at age 6 rather than age 5, there is much closer correspondence between the data sets.

In any event, both sets of data indicate that the incremental increases in length of female rock sole, at least between ages 5 and 13, is greater on the Scott Island grounds than on the Butterworth grounds.

No attempt has been made to compare growth of male rock sole from age-length and tagging data because the numbers of usable tagged fish were too few. Besides, the length range of male fish and their much slower growth rate are not amenable to the technique of comparison used here.

DISCUSSION AND CONCLUSIONS

From taggings on the Butterworth grounds in northern Hecate Strait (Minor Area 4 in Major Area 5D) only three recaptures (one confirmed) or 0.5% were made in other minor areas. Excluding first-year recaptures, over 85% were made within 10 mi of the place of release, and greatest net movement was only 41 mi. Low fishing effort in minor areas other than Area 4 was a contributing factor to the apparently low level of dispersion. However tagging in those other minor areas (within Area 5D), resulted in no recaptures on the Butterworth Grounds.

No recaptures from tagging on the "Ole Spot" in Major Area 5C were made either on the nearby Horseshoe Ground or anywhere in Major Area 5D. It was concluded that Hecate Strait supports a number of largely independent stocks. If there are significant movements other than the spring-summer northward movement of 10-15 mi noted by Forrester and Thomson (1969), they occur during the late fall and winter and straying appears to be an uncommon event limited to distances less than 50 mi.

Tagging on the Goose Island and Scott Island grounds (Areas 5B and 5A, respectively) in Queen Charlotte Sound resulted in a high proportion of recaptures (85%) on the grounds where they were released (even when first-year returns are excluded), suggesting that rock sole in the two major areas can be treated as essentially independent stocks. Although nine returns were reported on the Scott Island Grounds from tagging on Goose Island Bank, none could be confirmed on the basis of criteria used in this report. No confirmed recaptures were made in Hecate Strait or on grounds along the west coast of Vancouver Island (Major Areas 3C and 3D).

The general conclusion to be drawn from the 1946-66 taggings in Hecate Strait and Queen Charlotte Sound is that rock sole occur along the British Columbia coast in a number of largely independent populations in each of the major statistical areas and possibly in smaller segments of those areas.

It is pertinent to note that rock sole, in common with lingcod (Ophiodon elongatus) produce sticky adhesive eggs. Both species are relatively sedentary in contrast to English sole (Parophrys velulus) and some other flatfishes that engage in significant pre-spawning "up-stream" migrations to compensate for drift during the pelagic egg and larval stages. A seasonal north-south pattern of English sole migration from the northern portion of Minor Area 4 to Area 5U in central Hecate Strait (see Fig. 2) has already been documented (Ketchen 1956). Substantial migrations of this species have also been recorded from the Strait of Georgia (Ketchen and Forrester 1955) in which area limited results of rock sole tagging (Project 4 in Table 2) in contrast revealed no movement out of the minor area where tagging took place.

SUMMARY

1. This report provides an inventory of rock sole taggings conducted in British Columbia waters from 1944 to 1966 (Tables 1 and 2). During that period over 11,000 fish were tagged, the majority of the releases having been made on the major rock sole fishing grounds of Hecate Strait and Queen Charlotte Sound. Results for these areas were subjected to detailed study.

2. Excluding the first year, over 85% of recaptures from tagging on the Butterworth Ground in northern Hecate Strait (Major Area 5D) were made within 10 mi of the release site. Greatest net movement was less than 50 mi.

3. Tagging in other minor areas within Area 5D resulted in no recaptures on the Butterworth Ground.

4. No recaptures from tagging on the Ole Spot in southern Hecate Strait (Major Area 5C) were made on the nearby Horseshoe Ground or anywhere in Area 5D.

5. On Cook Bank and Goose Island Bank in Queen Charlotte Sound (Major Areas 5A and 5B, respectively) a high proportion of recaptures (85%) was made on the banks where the fish were released. Nine unconfirmed reports of recaptures on Cook Bank from tagging on Goose Island Bank are regarded as questionable evidence of mixing between banks. No confirmed recaptures were made in Hecate Strait or on grounds off the west coast of Vancouver Island.

6. It was concluded that Hecate Strait and Queen Charlotte Sound support a number of largely independent stocks in each of the major statistical areas and possibly in smaller segments of those areas.

7. On the Butterworth Ground, growth of female rock sole as determined from recaptured fish compared well with growth calculated from age-length data to about age 9 yr. Increasing disparity thereafter suggests a tendency to under-estimate age of older fish from otoliths. However such error appears to be of minor importance since 84% of the commercial catch consists of fish age 7 or less.

8. For the Scott Island grounds on Cook Bank a similar comparison showed little difference in growth rate for young and old age classes but some disparity for intermediate ages (7-11 yr).

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Table 1. Tagging of rock sole conducted between 1944 and 1946.

Year	Month	Tagging site	Numbers tagged	Recaptures by year						
				1	2	3	4	5	Unk.	Total
Area 3C										
1945	June	Lennard Is. to Amphitrite Pt.	16	1	1	-	-	1	-	3
Area 4B										
1944	Oct-Nov	Johnstone and Queen Charlotte straits and adjacent inlets	270	1	0	1	-	-	-	2
1944	Nov	Cape Lazo to Porlier Pass	58	1	2	-	-	-	1	4
Area 5C										
1946	Aug-Sep	Horseshoe Ground	306	-	3	1	-	-	-	4
Area 5D										
1945	Mar-Apr	SW of Butterworth Rocks	24	3	-	-	-	-	-	3
	Sep	5 mi SW of Triple Island	8	-	-	1	-	-	-	1
1946	Jul	5 mi SW of Butterworth Rocks	144	1	8	1	-	-	-	10
Total			826	7	14	4	-	1	1	27

Table 2. Tagging of rock sole conducted from 1947 to 1966, inclusive, in chronological order.

Project no.	Year	Month	Statistical area		Tagging site	Number tagged	Total recapture	% recapture
			Major	Minor				
1	1947	Jun	5D	4	SW to S x W of Butterworth Rocks at a distance of 5-9 mi.	1,237	334	27.0
2	1948	Aug	5D	4	SW to S 1/2 W of Butterworth Rocks at a distance of 6-10 mi.	1,519	243	16.0
3	1952	May	5B	8	18 mi SW of Spider Island, or NE edge of Goose Island Bank.	539	92	17.1
4	1952	Oct	4B	14	Cape Lazo to French Creek	506	96	19.0
5	1953	Jun	5B	8	NE to NW corner of Goose Island Bank	756	184	24.3
6	1954	May	5B	8	NE corner of Goose Island Bank	300	87	29.0
7	1954	Jun	5A	11	12 mi N 1/2 E of Cox Island	190	35	18.4
8	1958	Aug	5D	4	SW of Butterworth Rocks, 4 1/2-6 1/2 mi.	1,300	22	1.7
9	1958	Aug	5D	2AE	28 mi W of Bonilla Island	187	0	0.0
10	1958	Aug	5D	5U	8 mi WSW of White Rock Buoy	600	1	0.2
11	1959	Jul	5D	4	5 mi SW x S of Butterworth Rocks	1,300	34	2.6
12	1960	Jun	5A	11	12 mi N of Lanz Island	1,524	251	16.5
13	1966	Jun	5D	1E	2 mi off Wiah Pt., Dixon Entrance	184	14	7.6
14	1966	Jun	5C	2BE	20 mi SSW of Bonilla Island	252	6	2.4
Total						10,394	1,399	13.5

Table 3. Numbers of rock sole tag returns by month during the first year after tagging in the vicinity of Butterworth Rocks in northern Hecate Strait.

Year of tagging	Month	Numbers tagged	Month of recapture within first year												First year total	% recapture
			1*	2	3	4	5	6	7	8	9	10	11	12		
1947	Jun	1,240	117	62	10	18	-	-	-	-	-	1	2	11	221	17.8
1948	Aug	1,505	105	46	4	1	-	-	-	-	-	23	12	5	196	13.0
1958	Aug	1,300	8	2	1	1	3	-	-	-	-	-	-	-	15	1.2
1959	Jul	1,300	-	-	-	-	-	-	-	-	-	-	-	12	12	1.8
Total		5,345	230	110	15	20	3	-	-	-	-	24	14	28	444	8.3

*First calendar month following date of release.

Table 4. Numbers of rock sole tag returns by year from tagging conducted in the vicinity of Butterworth Rocks in northern Hecate Strait.

Year of tagging	Years from tagging											
	1*	2	3	4	5	6	7	8	9	Unk.	Total	% recapture
1947	221	66	22	16	2	2	-	-	1	4	334	26.9
1948	196	22	19	2	2	-	1	-	-	1	243	16.1
1958	15	3	1	2	1	-	-	-	-	-	22	1.7
1959	12	18	3	-	-	-	-	-	1	-	34	4.3
Total	444	113	46	20	5	2	1	-	2	5	633	13.1

*First 12 mo (total from Table 3).

Table 5. Length composition of rock sole tagged on the Butterworth Rocks Grounds of northern Hecate Strait (Area 5D) during 1947-1959.

Project no. Year		1 1947	2 1948	7 1958	10 1959
Length group:					
< 31 cm	No.	105	223	725	518
	%	(8.5)	(14.6)	(55.8)	(39.9)
31-35 cm	No.	605	440	475	640
	%	(48.9)	(29.0)	(36.5)	(49.2)
36-40 cm	No.	321	562	81	132
	%	(25.9)	(37.0)	(6.2)	(10.1)
41-45 cm	No.	167	246	14	9
	%	(13.5)	(16.2)	(1.1)	(0.7)
46-50 cm	No.	37	47	5	1
	%	(3.0)	(3.1)	(0.4)	(0.1)
> 50 cm	No.	2	1	-	-
	%	(0.2)	(0.1)		
Total	No.	1,237	1,519	1,300	1,300
	%	(100.0)	(100.0)	(100.0)	(100.0

Table 6. Dispersion of tagged rock sole after at least 1 yr at liberty frm tagging sites on the Butterworth Ground of northern Hecate Strait (Area 5D, Minor Area 4). Percentages shown in parenthesis.

Net distance (naut mi)	1947	1948	1958	1959	Total
0-5	65 (61.3)	35 (42.2)	7	13	120 (56.6)
6-10	25 (23.6)	33 (39.8)	1	1	60 (28.3)
11-15	8 (7.5)	12 (14.5)		-	20 (9.4)
16-20	3 (2.8)	3		-	6 (2.8)
21-25	3 (2.8)	-		-	3 (1.4)
26-30	-	-		-	
31-35	-	-		-	
36-40	2* (1.9)	-		-	2 (0.9)
>40	-	-		1**	1 (0.5)
Total	106	83	8	15	212

*One unconfirmed and one partly confirmed: 40 mi from tagging site (8 mi southwest of White Rocks in Minor Area 5U) after 5 yr at liberty.

**Fully confirmed - 46 mi from tagging site (18 1/4 mi south-southwest of White Rocks) after 8 yr at liberty.

Table 7. Canadian landings of rock sole by minor areas in Dixon Entrance and Hecate Strait (figures in thousands of pounds).[a]

Year	1E	2AE	4	5U	5L	2BE
1946	-	-	788	61	-	54
47	0	0	2,265	47	-	292
48	-	-	1,851	53	-	82
49	-	2	1,230	43	-	174
1950	-	-	1,452	1	-	17
51	-	1	2,401	92	-	371
52	-	-	4,689	221	27	166
53	-	-	1,066	1	-	445
54	-	50	1,973	2	-	100
1955	-	1	2,639	26	-	235
56	-	709	743	9	1	835
57	1	426	372	52	-	1,600
58	-	123	1,627	69	-	757
59	-	32	331	2	-	349
1960	-	1	1,347	72	-	835
61	1	-	1,340	56	-	210
62	1	-	1,082	10	2	635
63	14	-	1,566	13	-	305
64	4	1	965	124	-	527
1965	18	16	682	33	-	1,152
66	315	12	2,883	159	41	2,130
67	25	111	2,279	217	61	1,742
68	180	27	2,824	394	144	1,684
69	41	3	2,671	267	72	2,264
1970	10	24	993	449	5	1,605
71	16	*	1,961	476	-	915
72	7	1	608	249	-	358
73	2	4	394	259	-	450
74	99	5	384	254	-	629
1975	16	-	1,206	586	-	951
76	38	-	1,930	591	27	579
77	10	38	931	288	4	585
78	9	9	854	269	7	784
79	72	1	722	674	205	1,224
1980	162	3	632	294	2	1,058

[a]Throughout the recorded history of United States fishing in Hecate Strait (1956-70) landings by that country were of little consequence, averaging 107,000 lb with largest landing being 347,000 lb in 1967.

Table 8. Number of rock sole tag returns by month during the first year after tagging on grounds other than Butterworth in Major Areas 5D (Projects 9-13) and 5C (Project 14).

Project no.	Minor area	Month of recapture within first year											First year total	% recapture
		1*	2	3	4	5	6	7	8	9	10	Unk.		
9	2AE	-	-	-	-	-	-	-	-	-	-	-	0	0.0
10	5U	-	-	-	-	-	-	-	-	-	-	-	0	0.0
13	1E	-	-	-	4	2	-	-	-	1	-	-	7	3.8
14	2BE	-	-	1	-	-	-	-	-	-	1	-	2	0.8

*First calendar month following release.

Table 9. Number of rock sole tag returns by year, from tagging conducted on grounds other than Butterworth in Hecate Strait-Dixon Entrance (Area 5C + 5D).

Project no.	Minor area	Years from tagging						Total	% Recapture
		1*	2	3	4	5	Unk.		
9	2AE	-	-	-	-	-	-	0	0.0
10	5U	-	-	-	-	-	1	1	0.2
13	1E	7	6	1	-	-	-	14	7.6
14	2BE	2	1	2	1	-	-	6	2.4

*First 12 mo (total from Table 8).

Table 10. Length composition of rock sole used in miscellaneous minor taggings from Dixon Entrance to west of Bonilla Island in Area 5D (Projects 9, 10, 13) and south-southwest of Bonilla Island in Area 5C (Project 14).

Minor statistical area		2AE	5U	1E	2BE
Project no.		9	10	13	14
Year		1958	1958	1966	1966
Length group:					
< 31 cm	No.	109	234	4	1
	%	(58.3)	(39.0)	(2.2)	(0.4)
31-35 cm	No.	47	118	49	25
	%	(25.1)	(19.6)	(26.6)	(9.9)
36-40 cm	No.	22	127	84	120
	%	(11.8)	(21.2)	(45.7)	(47.6)
41-45 cm	No.	9	111	39	99
	%	(4.8)	(18.5)	(21.2)	(39.3)
46-50 cm	No.	-	9	7	7
	%	-	(1.5)	(3.8)	(2.8)
> 50 cm	No.	-	1	1	-
	%	-	(0.2)	(0.5)	-
Total	No.	187	600	184	252
	%	(100.0)	(100.0)	(100.0)	(100.0)

Table 11. Length composition of rock sole tagged on the Goose Island Grounds (Projects 3, 5, and 6) and on Scott Island Grounds (Projects 9 and 12) in Queen Charlotte Sound during 1952-1960.

		Goose Island Grounds			Scott Islands Grounds	
Project no.		3	5	6	13	14
Year		1952	1953	1954	1966	1966
Length group:						
<31 cm	No.	40	50	14	4	73
	%	(7.4)	(6.6)	(4.7)	(2.1)	(4.8)
31-35 cm	No.	229	392	106	34	443
	%	(42.5)	(51.9)	(35.3)	(17.9)	(29.1)
36-40 cm	No.	190	250	121	79	475
	%	(35.2)	(33.1)	(40.3)	(41.6)	(31.1)
41-45 cm	No.	73	55	47	46	381
	%	(13.5)	(7.3)	(15.7)	(24.2)	(25.0)
46-50 cm	No.	7	8	11	24	142
	%	(1.4)	(1.0)	(3.7)	(12.6)	(9.3)
>50 cm	No.	-	1	1	3	10
	%		(0.1)	(0.3)	(1.6)	(0.7)
Total	No.	539	756	300	190	1524
	%	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)

Table 12. Numbers of rock sole tag returns by month during the firt year after tagging in Queen Charlotte Soudn (Area 5A--NNW of Cox Island; Area 5B--between the NW and NE corners of Goose Island Bank.

Year of tagging	Month	Numbers tagged	Recaptures by month within first year												First year total	% Recap.
			1*	2	3	4	5	6	7	8	9	10	11	12		
Area 5A																
1954	Jun	190	5	4	2	-	-	-	-	-	-	-	-	-	11	5.8
1960	Jun	1530	12	51	38	10	2	-	-	-	-	2	10	11	136	8.9
Total		1710	17	55	40	10	2	-	-	-	-	2	10	11	147	8.6
Area 5B																
1952	May	535	13	19	12	24	11	2	-	-	-	-	1	-	82	15.3
1953	Jun	758	-	67	25	26	-	-	-	-	-	8	-	3	129	17.0
1954	May	300	-	-	2	1	9	5	-	-	-	-	-	-	17	5.7
Total		1593	13	86	39	51	20	7	-	-	-	8	1	3	228	14.3

*First calendar month after release.

Table 13. Numbers of rock sole tag returns by year from taggings conducted in Queen Charlotte Sound.

Year of tagging	Recaptures by year									Total recap.	% Recap.
	1*	2	3	4	5	6	7	8	Unk.		
Area 5A											
1954	11	9	10	3	2	-	-	-	-	35	18.4
1960	136	50	44	14	3	2	2	-	-	251	16.5
Total	147	59	54	17	5	2	2			286	16.7
Area 5B											
1952	82	8	1	-	-	-	-	-	-	92	17.2
1953	129	26	9	11	8	-	-	-	1	184	24.3
1954	17	40	21	3	6	-	-	-	-	87	30.7
Total	228	74	31	15	14	3	1	1	1	363	23.1

*First 12 months (total from Table 12).

Table 14. Landings of rock sole from the two principal fishing grounds in Queen Charlotte Sound (figures in thousands of pounds).

	Major Area 5A Scott Island Grounds			Major Area 5B Goose Island Grounds		
Year	Canada	U.S.A.	Total	Canada	U.S.A.	Total
1952	352	?	?	235	?	?
53	116	?	?	86	?	?
54	72	?	?	187	?	?
1955	135	?	?	287	?	?
56	939	274	1,213	592	92	684
57	1,062	63	1,125	389	54	443
58	1,034	72	1,106	700	132	832
59	366	101	467	679	80	759
1960	713	162	875	858	252	1,110
61	436	86	522	594	322	916
62	364	68	432	779	392	1,171
63	242	113	355	616	524	1,140
64	291	54	345	377	685	1,062
1965	130	394	524	137	260	397
66	476	151	727	607	1,095	1,702
67	482	74	556	365	1,269	1,634

Table 15. Disperson of tagged rock sole after at least one year at liberty from taggings conducted in Queen Charlotte Sound (percentages in parentheses).

Tagging area	Area 5A Cook Bank			Area 5B Goose Island Bank			
Year	1954	1960	Total	1952	1953	1954	Total
Net distance							
Naut mi.							
0-5	8	25	33 (28.4)	-	16	2	18 (30.5)
6-10	3	40	43 (37.1)	4	9	-	13 (22.0)
11-15	2	27	29 (25.0)	-	8	6	14 (23.7)
16-20	-	7	7 (6.0)	-	-	1	1 (1.7)
21-25	-	1	1 (0.9)	-	2	3[a]	5 (8.5)
26-30	-	3[f]	3 (2.6)	-	-	2[b]	2 (3.4)
31-35	-	-	-	-	1[c]	2[d]	3 (5.2)
36-40	-	-	-	-	2[e]	-	2 (3.5)
Total	13	103	116	4	38	16	59

[a]Includes one reported capture on Scott Island Grounds (23 mi)
[b]One reported recaptured on Scott Island Grounds (30 mi) and one on Virgin Rocks Ground (26 mi).
[c]Reported from Scott Island Grounds (38 mi)
[d]Reported from Scott Island Grounds (37 and 38 mi)
[e]Reported from Scott Island Grounds (53 and 60 mi)
[f]Reported near Cape Palmerston.

Table 16. Details on tagged rock sole released on the Goose Island Grounds in 1953 and 1954 (Projects 5 and 6) and allegedly recaptured to the south on the Scott Island Grounds or Virgin Rock Ground.

Release information					Recapture information					
Project no.	Tag no.	Date	Locality	Length & sex (cm)	Date	Vessel	Locality	Length (cm)	Mo. at liberty	Distance (naut mi)
5	D8803	Jun 12 1953	NW Corner	36 F	May 19 1956	Sea Pride II	12 mi NW of Cox Island	43.8	35	53
5	D8812	Jun 12 1953	NW Corner	39 F	Mar 28 1957	Luanna S	9 mi W of Bull Harbour	45.7	45	60
5	D8842	Jun 13 1953	NE Corner	34 F	Jun 16 1957	[a]	16 mi WxS of Mexicana Pt.	41.0	48	32
5	D8883	Jun 13 1953	NE Corner	37 F	Mar 28 1957	Luanna S	9 mi W of Bull Harbour	43.5	45	38
6	M4236	May 17 1954	NE Corner	36 F	Jul 15 1956	Cape Norman	9 mi W 1/4 S of Mexicana Pt.	42.9	24	37
6	M4282	May 17 1954	NE Corner	37 F	May 26 1961	Cape Norman	10 mi W of Egg Island[b]	46.0	84	26
6	M4438	May 17 1954	NE Corner	32 F	Jul 19 1957	B. C. Producer	30 mi W. of Mexicana Pt.	42.9	38	24
6	M4510	May 17 1954	NE Corner	32 M	Jun 9 1955	Zorina	24 mi WxS of Mexicana Pt.	31.1	13	30
6	M4515	May 17 1954	NE Corner	34 F	Jun 4 1956	Sea Pride II	8 mi N of Cox Island	42.0	24	38

[a]Name of vessel not recorded, but apparently was known to the recorder.
[b]Virgin Rock grounds in Sea Otter Group. All others localities refer to Scott Island grounds.

Table 17. Growth parameters for female rock sole as obtained from tagging results, compared with published results from age-length studies using otoliths.

Parameter	Butterworth Ground			Goose Island Grounds	Scott Island Ground	
	Tagging results	Forrester and Thomson (1969)[a]	Stocker (1982)[b]	Tagging results	Tagging results	Chilton and Smith (1971)[c]
K	0.22	0.15	0.21	0.32	0.15	0.07
L_∞ (cm)	47.1	51.6	50.7	50.7	54.2	70.6
t_o (yr)	N/A	-2.50	-0.13	N/A	N/A	-5.70

[a]Parameters apply to 1945-58.
[b]Parameters apply to 1945-78.
[c]Parameters calculated from raw data provided by these authors.

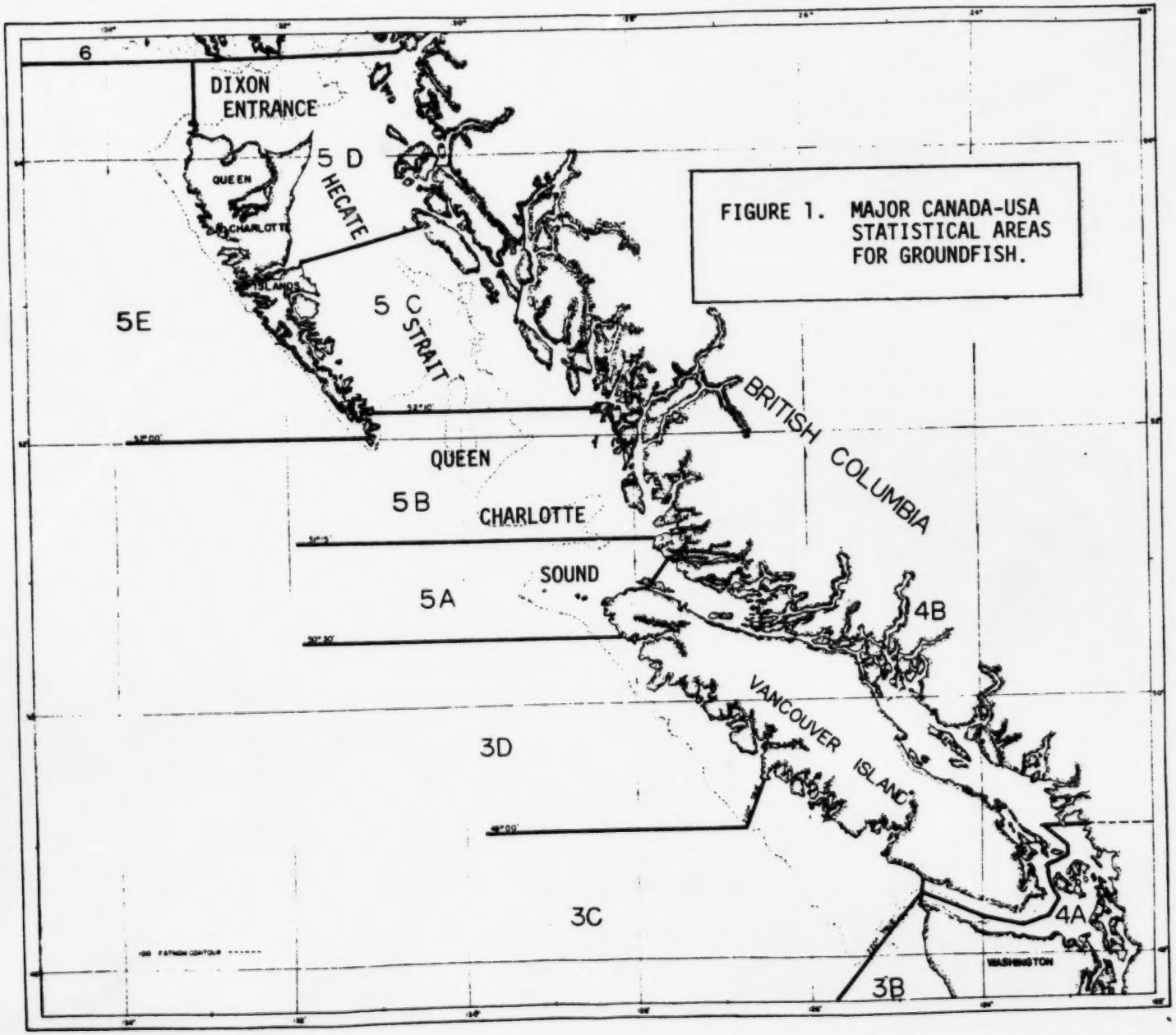
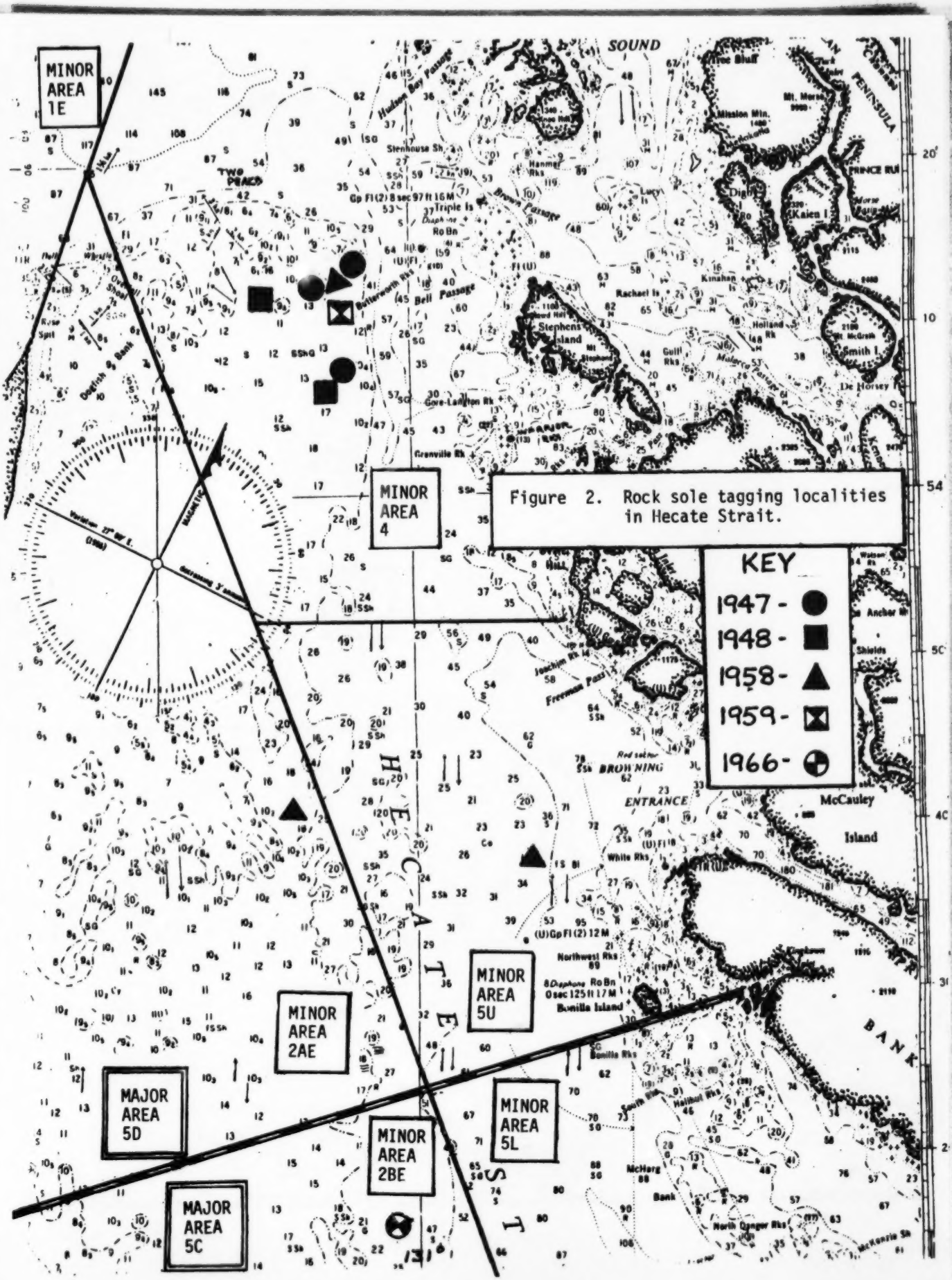


FIGURE 1. MAJOR CANADA-USA STATISTICAL AREAS FOR GROUNDFISH.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MINOR AREA 4
MINOR AREA 2AE
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MINOR AREA 5U
MINOR AREA 5L
MAJOR AREA 5D
MAJOR AREA 5C
KEY
1947 -
1948 -
1958 -
1959 -
1966 -
HECATE STRAIT
SOUND
BANK
ENTRANCE
BROWNING
McCauley Island
Dundas Island
Triple Is
Stephens Island
Smith I
Kaien I
Digby I
Rachael Is
Kinahan Is
Holland Rk
Gull Rks
Hudson Bay Passage
Stenhouse Sh
Hanmer Rks
Butterworth Rks
Bell Passage
Gore-Langton Rk
Grenville Rk
Joachim Rk
Freeman Pass
Northwest Rks
Bonilla Island
Bonilla Rks
South Rk
Halibut Rk
McHarg Bank
North Danger Rks
White Rks
Mission Mtn
Mt. Morse
Lucy I
Anchor Rk
Shields
Watson Rk
Figure 2. Rock sole tagging localities in Hecate Strait.

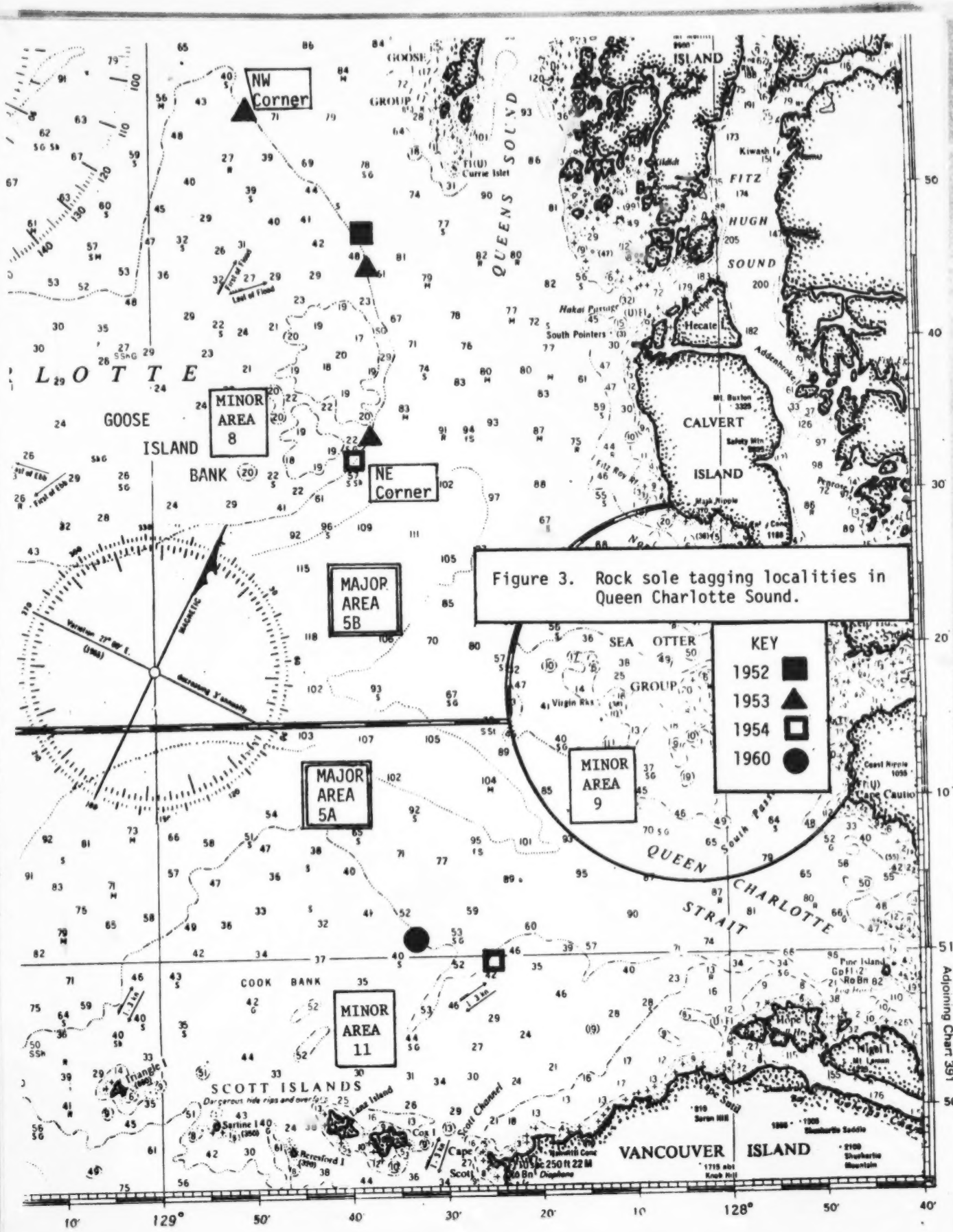

Figure 3. Rock sole tagging localities in Queen Charlotte Sound.

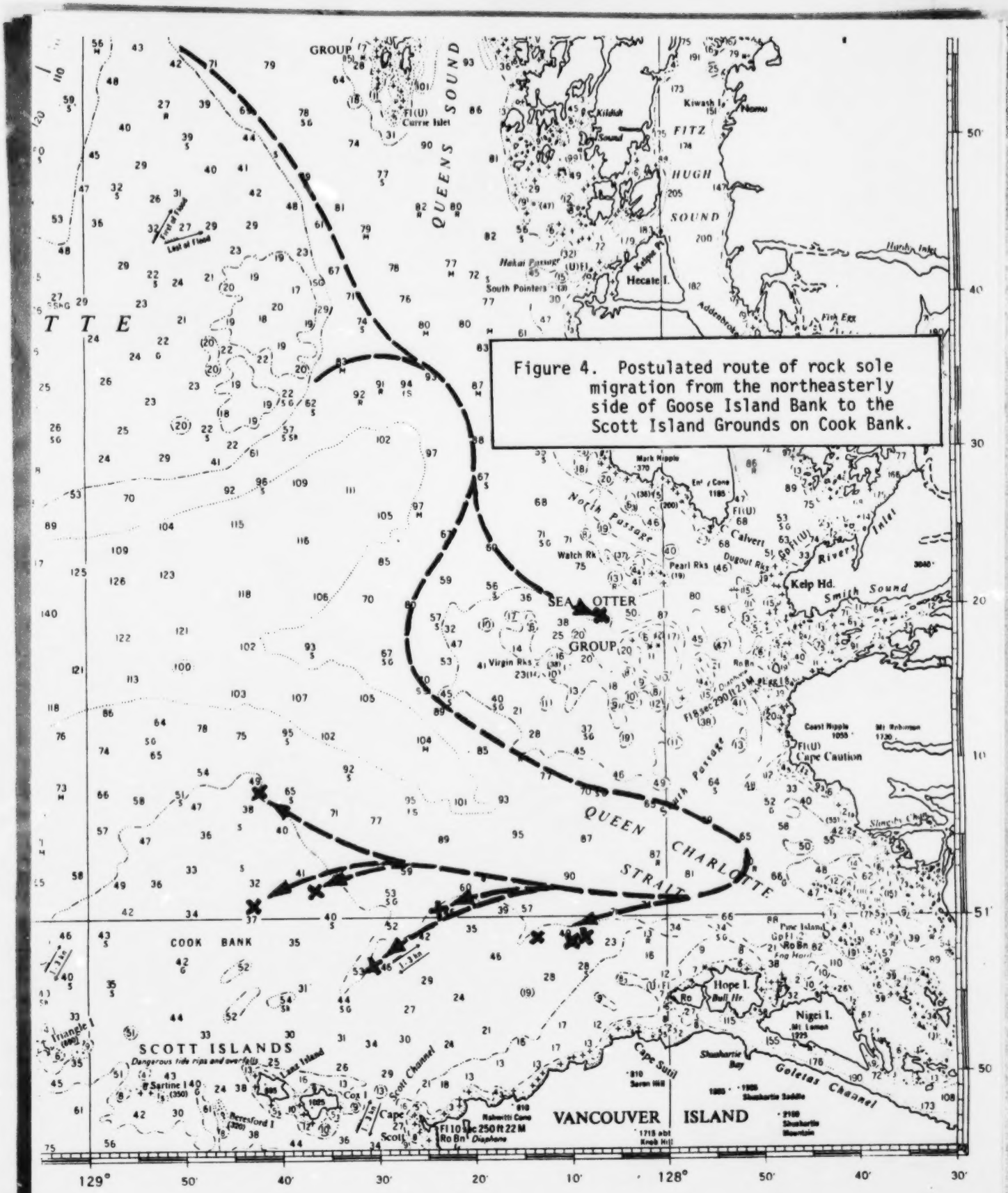

Figure 4. Postulated route of rock sole migration from the northeasterly side of Goose Island Bank to the Scott Island Grounds on Cook Bank.

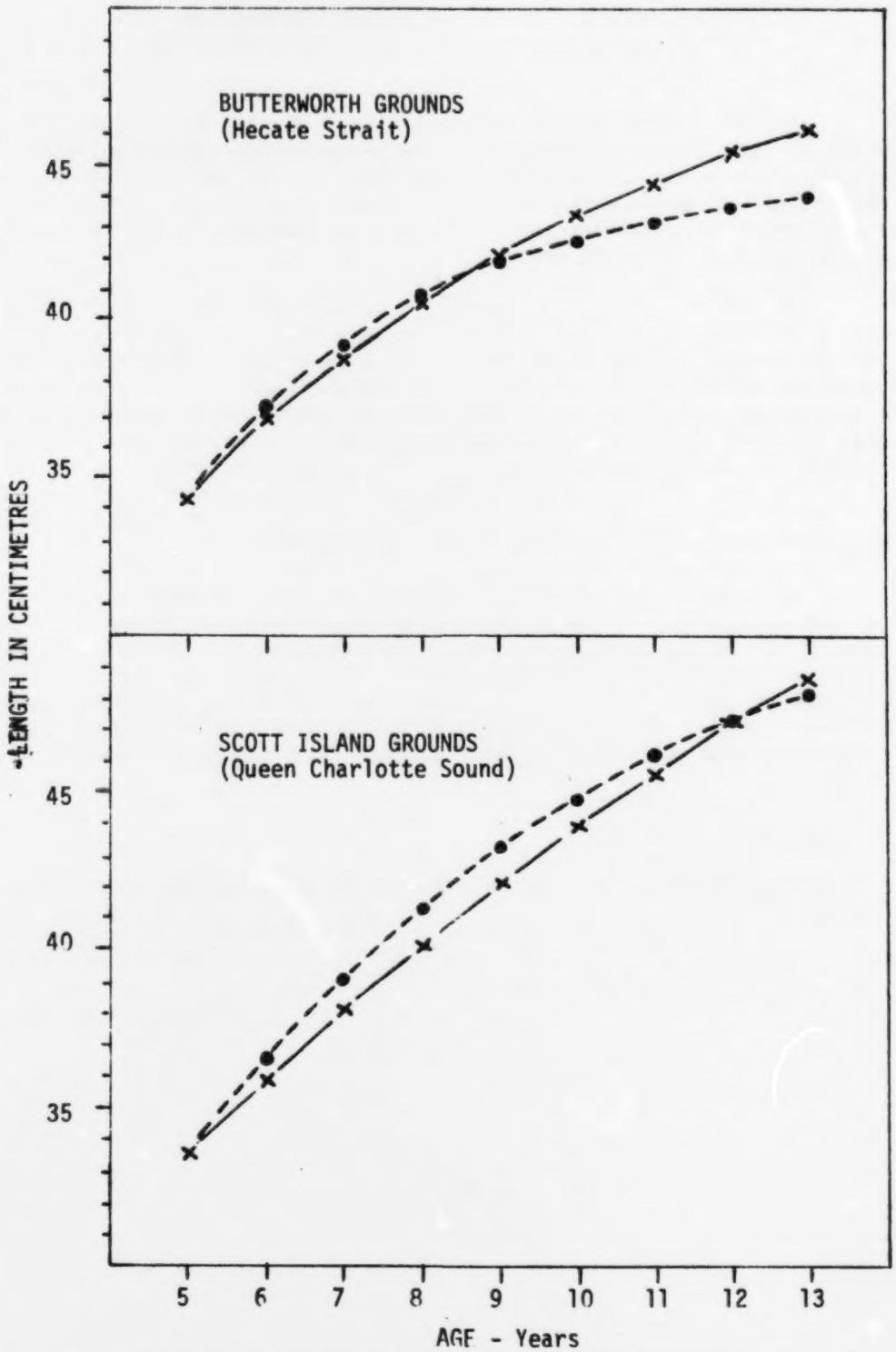

Figure 5. Size at age of rock sole, as determined from otolith readings (solid line) and from tag and recapture information (broken line). See text for details.

APPENDIX I

ACCURACY OF TAG RECAPTURE INFORMATION

In the present report the writer has taken at face value the accuracy of information on the particular place where tagged rock sole were recaptured. In so doing he has presumed that, in the overall picture, errors in the calculated net distance travelled tend to cancel out. While this may well be true it is important that the reader be familiar with the sources and possible magnitude of those errors.

In the first place the sites of release as given in Table 2 are not nearly so accurate as implied. In the 1940s-1950s, research vessel position was established by taking fixes from visible land features, or if visibility was poor, by dead-reckoning based on compass bearings and cruising speed. With arrival of radar this guess-work was reduced if not eliminated where grounds were within the effective working range of that equipment. Once on the ground, it was the usual practice of the skipper to provide a fix for the start of the tow. Small changes in position during the course of a day (say plus or minus 2 mi) probably were ignored by the biologist aboard, especially if his conscientiousness had been eroded by mal de mer.

Accuracy of tag recapture information was even more subject to error, not only because of misjudgement of distances from landmarks[1], but also because of the problems of reporting. A few fishermen would have the time or interest to identify a particular recapture with a particular day or drag. However, the majority would be more likely to give a trip position, probably determined by the best fishing spot and the usual direction and distance travelled from the over-night anchoring place used during the course of any one trip.

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[1]Radar and LORAN A were not in wide use by the Canadian trawl fleet until the 1960s.

APPENDIX 2

CONFIRMATION OF TAG RECAPTURE INFORMATION

When tagged fish are allegedly recaptured at long distance from point of release they are likely to have important bearing on the definition of stocks (if such has not already been established), on the definition of management areas and consequently on management decisions. Accordingly they should be subjected to a rigid verification procedure. In the present study of rock sole tag returns a CONFIRMED RECAPTURE had to meet the following criteria:

1. A premium reward was paid to the vessel skipper. In tag return records for the 1940s to 1960s such a payment was $0.75 as opposed to the standard reward of $0.50. The former means that the port observer was presented with the fish with tag *in situ*.[1] Receiving it directly from the skipper meant there was no doubt as to the vessel from which the tag originated.

2. The tag and vessel information can be linked to a particular trip report showing that the vessel did *not* fish on the ground or bank where the tagged fish was released.

An UNCONFIRMED RECAPTURE may be one for which a premium was paid but which lacked information on vessel of origin (e.g. discovery was made by a shoreworker) and/or the possibility existed the recapture was made in the area of tagging. All standard-reward tags would of course be assigned to the unconfirmed category, because of the indefiniteness or hearsay nature of the accompanying evidence.

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[1] At least until the middle 1960s, trawlers landed their catches stored in ice. If the skipper produced both the tag and the fish there could be no question that it was caught during the trip in question. Today, this criterion has limited use because the skipper, by one of various means available to him, may be able to keep a tagged fish in a frozen condition for more than the duration of one trip.

Appendix 3. Lengths of female rock sole at time of tagging (ℓ_t) on the Butterworth Ground compared with lengths at recapture (ℓ_{t+1}) in the 11-13-mo interval after release (lengths in millimeters).

ℓ t	ℓ t+1	ℓ t	ℓ t+1	ℓ t	ℓ t+1	ℓ t	ℓ t+1
		Butterworth (1947, 1948 and 1959 taggings)					
280	350	335	360	380	400	400	450
290	350	340	350	380	380	420	420
300	315	340	370	380	390	420	420
310	360	340	360	380	400	430	430
310	330	340	355	380	400	440	455
310	330	350	355	380	394	450	460
310	355	355	365	380	384	450	450
320	370	355	380	390	410	460	460
330	378	370	390	390	400		
330	360	370	390	390	420		
330	370	370	400	400	430		
		Goose Island (1952, 1953 and 1954 taggings)					
300	368	345	387	400	428	415	464
310	356	350	368	400	438	420	457
325	378	355	387	400	416	430	470
325	368	365	422	405	432	430	441
330	394	365	432	405	441		
340	368	370	381	415	432		
		Scott Island (1954 and 1960 taggings)					
270	283	350	381	390	416	410	429
300	327	360	381	390	413	420	445
310	318	360	384	390	410	420	438
320	330	370	387	390	413	420	438
320	330	370	387	390	413	420	438
340	368	370	398	390	419	430	448
340	59	380	413	400	432	430	451
340	384	380	422	400	429	440	440
340	403	380	406	400	410	440	467
350	362	380	387	400	416	460	470
350	375	390	413	410	425		
350	413	390	403	410	419		
350	391	390	410	420	445		